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(54) **Substrate for catalytic system and ferritic stainless steel from which it is formed.**

(57) A system comprising a ferritic stainless steel substrate having a tightly adherent oxide coating and a catalytic material thereupon, and the ferritic stainless steel from which the substrate is formed. The ferritic stainless steel is of a chemistry which forms a tightly adherent non-spalling scale suitable for application of a catalytic bearing material and consists essentially of, by weight, up to 26% chromium, from 1 to 8% aluminium, between 0.01 and 0.1% yttrium, up to 0.1% carbon, up to 2% silicon, balance essentially iron.

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SUBSTRATE FOR CATALYTIC SYSTEM AND FERRITIC STAINLESS STEEL FROM WHICH IT IS FORMED

The present invention relates to a system comprising a substrate and a catalytic material and to the alloy from which the substrate is formed.

As the particular material used as a substrate for the catalyst in automotive catalytic convertors affects the performance of the convertors, there is a need to develop improved substrates. In particular, there is a need for a metallic substrate to replace the ceramic substrates presently in use. Ceramic substrates do not have the mechanical properties; e.g., shock resistance, of metallic substrates. Ceramic substrates are, in addition, inherently thicker than are metallic substrates.

A particular metallic substrate is described in United States Patent No. 3,920,583. It is a ferritic stainless steel which contains up to 15% chromium, 0.5% to 12% aluminium and 0.1 to 3% yttrium.

Economic and technical problems have been encountered

with the use of yttrium, thereby detracting from the benefits of the substrate of United States Patent No. 3,920,583. Yttrium is an expensive material which is not presently available in abundant quantities, and a material characterized by a low recovery rate during melting.

Through the present invention there is provided a metallic substrate which minimizes the difficulties associated with the substrate of Patent No. 3,920,583. The present invention relates to a substrate wherein the yttrium level of Patent No. 3,920,583 is significantly reduced. It has been determined that high quality substrates can be produced from iron-chromium-aluminium alloys having less than 0.1% yttrium.

Other references disclosing ferritic stainless steels with chromium, aluminium, and yttrium are United States Patent Nos. 3,027,252 and 3,298,826, and reports respectively entitled, "The Physical Metallurgy And Oxidation Behavior Of Fe-Cr-Al-Y Alloys" and "Sulfidation - Resistant Alloy For Coal Gasification Service". The first report is dated June 1, 1966. It was prepared by C. S. Wukusick under United States Atomic Energy Commission Contract No. AT(40-1)-2847. The second report was published June 14, 1977. It was prepared by Roger A. Perkins and M. S. Bhat for the U. S. Energy Research And Development Administration under Contract No. E(49-18)-2299.

Neither the reports nor the patents relate to a substrate for a catalytic material nor to an alloy having less than 0.1% yttrium.

Another reference disclosing ferritic stainless steels with chromium, aluminium and yttrium is United States Patent No, 3,591,365. Although it discloses alloys which may have less than 0.1% yttrium, its alloys require specific additions of gadolinium and/or dysprosium. As with the references disclosed in the preceding paragraphs, it does not pertain to substrates for catalytic materials.

It is accordingly an object of the subject invention to provide a substrate for a catalytic material and an alloy from which the substrate is formed.

The present invention provides a system comprising a ferritic stainless steel substrate having a tightly adherent oxide coating and a catalytic material thereupon, said ferritic stainless steel being of a chemistry which forms a tightly adherent non-spalling scale suitable for application of a catalytic bearing material; characterized in that the ferritic stainless steel substrate consists essentially of, by weight, up to 26% chromium, from 1 to 8% aluminium, between 0.01 and 0.1% yttrium, up to 0.1% carbon, up to 2% silicon, balance essentially iron.

The present invention further provides a ferritic stainless steel consisting essentially of, by weight, up to 26% chromium, from 1 to 8% aluminium, between 0.01 to 0.1% yttrium, up to 0.1% carbon, up to 2% silicon, balance

essentially iron.

The substrate is in most instances of a thickness of from 0.0127 to 0.254mm (0.0005 to 0.01 inch).

Chromium may be present within the substrate or steel of the present invention as it is known to improve oxidation resistance. A maximum limit is placed thereupon as chromium is expensive and renders the alloy more difficult to process. Chromium is usually present within the range of from 5 to 22%, and preferably within the range of from 12 to 20%.

Aluminium is present as it improves the oxidation resistance of the substrate or steel. A maximum limit is placed thereupon as aluminium, like chromium, is expensive and renders the alloy more difficult to process. Aluminium is preferably present within the range of from 3 to 6%.

Yttrium is present as it stabilizes the aluminium-bearing scale and makes it both tight and adherent. It is preferably present in amounts between 0.03 to 0.09%.

Carbon and silicon are preferably maintained at respective maximum levels of 0.03 and 0.5%. As ferritic stainless steels have inherently high transition temperatures, which rise with increasing carbon levels, low carbon contents should be specified in order to obtain a more ductile material.

The present invention is not dependent upon any particular means for manufacturing the catalytic system described herein. The system can be produced in accordance

with the teachings of heretofore referred to United States Patent No. 3,920,583, or by any other process known to those skilled in the art. Platinum, palladium, irridium, rhodium, and alloys thereof, are typical catalytic materials. The catalyst serves to provoke oxidation of partially oxidized hydrocarbons; e.g., CO to CO_2.

The following examples are illustrative of several aspects of the invention.

Several 0.0508mm (0.002 inch) thick Fe-Cr-Al alloys were subjected to a cyclic oxidation test in air at 1260°C (2300°F). The alloys were alternately resistance heated and cooled. Cycles to failure for each were recorded. Some of the samples had yttrium in excess of 0.1%. some were free of yttrium, and another had a yttrium level between 0.01 and 0.1%. The chemistry of the alloys appears hereinbelow in Table I. The carbon content for each is less than 0.03%.

TABLE I

	COMPOSITION (wt. %)			
Alloy	Cr	Al	Y	Fe
A*	16	5	0.23	Bal.
B	16	5.3	0.33	Bal.
C	16	5.3	0.40	Bal.
D	13	4.2	-	Bal.
E	16	5.2	-	Bal.
F	16	5.3	-	Bal.
G	16	4.0	0.08	Bal.

*Powder Metallurgy Heat

The results of the cyclic oxidation tests appear hereinbelow in Table II.

TABLE II

Alloy	Cycles to Failure*
A	124
B	161
C	204
D	9
E	27
F	111
G	144

*Average of several values

From Table II, it is noted that the oxidation resistance of Alloys A, B and C with yttrium contents in excess of 0.1% was superior to that for Alloys D, E and F which were devoid of yttrium, and that Alloy G with yttrium between 0.01 and 0.1% fared well in comparison with Alloys A, B and C. The results clearly show that iron-chromium-aluminium alloys with yttrium between 0.01 and 0.1% can be used as substrates for catalytic materials.

Claims:

1. A system comprising a ferritic stainless steel substrate having a tightly adherent oxide coating and a catalytic material thereupon, said ferritic stainless steel being of a chemistry which forms a tightly adherent non-spalling scale suitable for application of a catalytic bearing material; characterized in that the ferritic stainless steel substrate consists essentially of, by weight, up to 26% chromium, from 1 to 8% aluminium, between 0.01 and 0.1% yttrium, up to 0.1% carbon, up to 2% silicon, balance essentially iron.

2. A system according to claim 1, wherein said ferritic stainless steel substrate has from 5 to 22% chromium.

3. A system according to claim 2, wherein said ferritic stainless steel substrate has from 12 to 20% chromium.

4. A system according to claim 1, 2 or 3, wherein said ferritic stainless steel substrate has from 3 to 6% aluminium.

5. A system according to any one of the preceding claims, wherein said ferritic stainless steel substrate has from 0.03 to 0.09% yttrium.

6. A system according to any one of the preceding claims, wherein said ferritic stainless steel substrate has less than 0.03% carbon.

7. A system according to claim 1, wherein said ferritic stainless steel substrate has from 12 to 20% chromium, from 3 to 6% aluminium, between 0.03% and 0.09% yttrium and up to 0.03% carbon.

8. A ferritic stainless steel consisting essentially of, by weight, up to 26% chromium, from 1 to 8% aluminium, between 0.01 to 0.1% yttrium, up to 0.1% carbon, up to 2% silicon, balance essentially iron.

9. A ferritic stainless steel according to claim 8, having from 5 to 22% chromium.

10. A ferritic stainless steel according to claim 9, having from 12 to 20% chromium.

11. A ferritic stainless steel according to claim 8, 9 or 10, having from 3 to 6% aluminium.

12. A ferritic stainless steel according to any one of claims 8 to 11, having between 0.03 and 0.09% yttrium.

13. A ferritic stainless steel according to any one of claims 8 to 12, having up to 0.03% carbon.

14. A ferritic stainless steel according to any one of claims 8 to 13, having from 12 to 20% chromium, from 3 to 6% aluminium, between 0.03 and 0.09% yttrium and up to 0.03% carbon.